Growing Tomatoes in Glasshouses

By S. O. Gillard, Horticultural Instructor, Department of Agriculture, Auckland

N. Z. Department of Agriculture *Bulletin No. 370*

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Wellington, New Zealand, 1954

Climate, Soil, Site, Water Supply, Types of Houses

PRODUCTION of tomatoes under glass has become one of the most important features of commercial vegetable growing in New Zealand. A survey of glasshouse production of tomatoes conducted by the Department of Agriculture in 1950 showed that there were then about 1000 commercial growers, who operate some 2200 glasshouses, representing a total area of about 5,100,000 sq. ft. About 2,100,000 plants, with an average yield of 4½lb. per plant, are grown annually, Most of these crops are grown to supply the markets from May to February.

COMPARATIVELY few tomato glasshouses in the Auckland and Nelson Provinces are heated. In Hastings the proportion is much greater, and the importance of artificial heating increases in districts further south.

Two crops per year are grown in some districts in New Zealand. In the North Island heated houses are not always necessary to produce these crops; one is planted in January or February for an autumn and winter crop and one in June, July, or August for a spring crop. This practice allows an interval of only 3 to 4 weeks between the finish of the spring crop and the January or February planting of the next.

Methods of planting vary considerably. A number of growers plant on a level soil surface and ridge the soil up around the plants later. Others plant in wooden or concrete troughs (see "Tomato Culture in Troughs under Glass", "The New Zealand Journal of Agriculture", November 1948), a method mainly practised when excess soil moisture from adjacent land cannot be controlled. A few grow the crop in large pots or kerosene tins cut in halves; but the most widely used method is to plant in shallow depressions or trenches as described in this bulletin.

For the successful production of glasshouse tomatoes the important factors are climate, soil type, site, water supply, and shelter. The cost of establishing glasshouse units is high, so that full consideration must be given to all of these factors if losses or disappointing results are to be avoided.

Climate

It has been found that intensity of light and the total hours of bright sunshine are major factors in successful tomato production, and consequently sunny districts provide the best conditions for a heavy crop. Using light to the best advantage is also a first consideration for early or late crops and it has been found that glasshouses built east and west produce earlier crops in spring than do houses with their ends facing in other directions.

So that plants set out in glasshouses running east and west may receive the maximum of light it is recommended that plant rows be established crosswise in the house, that is, north and south. This method of planting, with its shorter rows, allows more convenient working of the growing crop than if plant rows are established lengthwise in the glasshouse.

Soil Types

Tomatoes are grown on many types of soil, including free-working volcanic and alluvial types and clay loams. The ideal soil is deep and well drained but with reasonably good moisture-holding capacity.

Soil water: The height of the water-table is important. Excess moisture close to the soil surface will create unfavourable conditions likely to hinder normal root development and will stimulate growth of fungi which destroy root tissue. Low soil temperatures brought about by excessive soil moisture will inhibit growth and delay the establishment of seedlings.

Few growers are fortunate enough to have the best type of soil, but those who are most successful have learnt not only how to obtain the best from the available soil, but ways to improve it by cultural practices and so overcome initial disadvantages.

Site

Particular attention should be given to choosing the position for a new glasshouse, as this may influence production even more than

does soil type. If possible, an almost level site should be chosen. It should be one that does not receive drainage water from neighbouring land and should be free of risk of infection by diseases carried in surface water.

It is an advantage if the land has a fall lengthwise of the house of 1in. to each 10ft., as this allows for the gutters under the eaves to be parallel with the surface of the ground. If the fall is more than 2in. in each 10ft., the glasshouse will be more expensive to erect, as levelling of the site will be necessary. The soil surface should be regular and free from hollows or ridges.

An area free from frosts is a decided advantage and will keep fuel costs down.

Water Supply

There should be a good water supply on the site, as during the season the crop requires a considerable amount of water—as much as 1 gallon of water per plant daily at some periods. Water is usually procured from mains through local bodies, and charges may vary according to district from 1s. 6d. to 2s. per 1000 gallons. A disadvantage of a town water supply service is that sometimes in drought periods, when the demand for water is heavy, the flow may be so reduced as to be insufficient to meet the requirements of commercial glasshouses.

Another source is a bore from which water is pumped up into a reservoir. This is satisfactory provided sufficient quantity can be obtained at a reasonable depth and the soluble salt content of the water is not excessive.

In some tomato growing areas the water supply is supplemented by large reservoirs filled by catchment rain-water from adjacent buildings. Whatever the source of water galvanised pipelines should service the glasshouses and should be large enough to allow for sufficient volume of water at all times. Large glasshouses usually have 1¼ to 2in. diameter piping fitted.

Shelter

A live shelter belt established against the prevailing winds is an advantage, provided it is not close enough to cause shading of the glasshouse or build-up of frosts. Sunlight is so essential to glasshouse work that shading for even an hour a day must be avoided if possible.

Types of Glasshouses

Though many types of glass structures are used for tomato growing, including houses with steel and wood frames, most of the houses in New Zealand have wood frames. The modern houses are simple and easy to operate and have very efficient ventilation systems. In the North Island in most of the new houses the rafters and studs are usually 24in. apart, allowing free passage of light. The side walls are usually 6ft. high and slope inward. These provide ample air space for the plants and comfortable working conditions. In the South Island most of the houses have vertical walls and the rafters and studs are mostly spaced 22in. apart.

Houses are usually 30 to 40ft. wide with varying lengths up to 200ft.. They are based on reinforced-concrete sidewall posts, concrete foundations, or on wooden posts.

Descriptions, of the construction of modern glasshouses were given in the following articles in "The New Zealand Journal of Agriculture": "Modern Tomato Glasshouses", January 1950; "Commercial Glasshouse Construction in Canterbury", June 1949 (but see also page 276 in September 1949 issue for correction of figures); and "Quonset-type Glasshouse", March 1951.

Support Wires

Plants are generally trained to produce up to nine trusses, seven below the support wire and two above. For this reason and to give head clearance the wires are set approximately 6ft. 6in. from the ground. The growing plants are supported by lengths of binder twine, around which they are trained. The twine is tied to the base of the plant at one end and at its other extremity to the overhead support wire.

Support wires are usually No. 10 galvanised plain wire and are run the same way as the plant rows. The plant rows may be placed either across the house or lengthwise to suit the convenience of the grower. Plants in rows planted north and south will receive the maximum light and normally are best orientated in this way.

Plant and Row Spacings, Varieties, Propagation

OPINIONS differ as to the best planting distances, but the most popular method is to set the plants in double rows 18in. apart with 30in. between double rows (see upper diagram on page 6). This system of planting gives the same average plant spacing as do single rows 24in. apart. The advantage gained is the convenience of the wider alternate rows for working.

The spacing of the plants and their supports has to be varied according to the spacing of the inner support posts so that the posts come between plant rows and are not in pathways, where they would be an obstruction during spraying, etc. This applies also to the floor markings for the plant beds and pathways when preparation for planting is undertaken. The following table sets out spacings for planting across the house (see also lower diagram on page 6):—

Distances apart of inner support posts ft.	
8	Support wires 18in. apart, 30in. between pairs of wires. Floor markings: 24in. plant bed and 24in. pathway.
8½	Support wires 21in. apart, 30in. between pairs of wires. Floor markings: 27in. plant bed and 24in. pathway.
9	Support wires 20in. apart, 34in. between pairs of wires. Floor markings: 26in. plant bed and 28in. pathway.

Crop Rotations

Rotation of crops is seldom practised by New Zealand glasshouse tomato growers, but it is usual to grow a green crop of maize, barley, or broad beans for digging in to improve the humus content of the soil. A few tomato growers grow such crops as lettuce, cucumbers, or beans as an alternative crop.

Varieties

The selection of the most suitable varieties for any particular locality is not easy, as factors such as soil type, environment, and methods practised by the grower influence production. The most popular variety at present is Potentate. Improved Bay State is also grown, but to a much less extent.

Potentate

Potentate came into popularity in 1944 and during the last 8 years it has been grown extensively. It produces medium to large, round, firm, fleshy fruit and crops heavily, especially on the first five trusses. Root development is not particularly strong, but the variety grows fairly well in soils treated with steam or chemicals. The fruits mature quickly. It prefers warmer and damper conditions than average tomato varieties and reacts to early dressings of nitrogen such as dried blood. It also shows some resistance to tomato leaf mould.

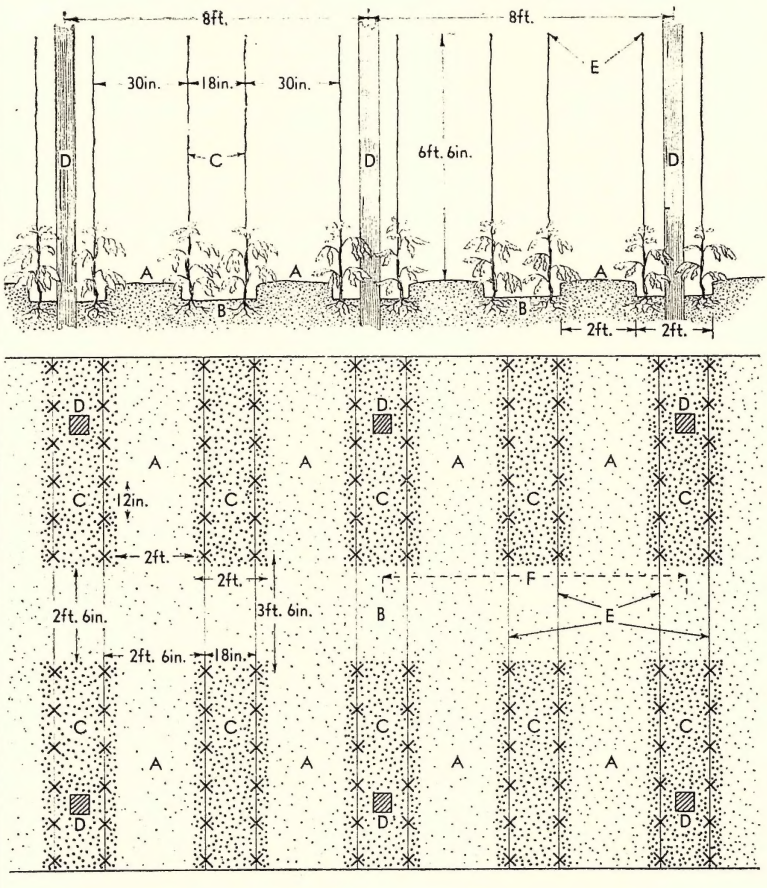
Improved Bay State

Improved Bay State, a variety obtained from America in 1948 and planted commercially 2 years later, produces slightly above medium to large, round, firm, fleshy fruits and crops heavily, especially above the third truss. The fruit tends to be pale until fully ripe and ripens about a week earlier than Potentate. Root development is usually very vigorous. The variety prefers warmer conditions than even Potentate and is highly resistant to tomato leaf mould.

Other Varieties

Other varieties grown to a much less extent are Kondine Red and Best of All. These varieties, however, are gradually losing favour.

A good practice is to test new varieties. In assessing the merits of a new variety attention should be paid to weight of crop, size of fruit, colour, firmness, and flavour. These characters are important, as they have a bearing on the market price, which is governed to some extent by the preference of the consumer. There is great variation within varieties and it is important to obtain the best strains for commercial plantings.



Diagrams showing method of planting in double rows across the house. Upper: Position of plants in relation to support posts and support wires. A—Paths. B—Trenches 4in. deep. C—Twine. D—Posts. E—Support wires. Lower: Plan of layout. A—Paths. B—Central path. C—Double rows forming plant beds. D—Posts. E—Support wires 6ft. 6in. above ground. F—Complete bay.

Propagation

Where propagation facilities and labour are available for the raising of plants for individual requirements it is strongly recommended that plants should be propagated by the grower, because the cost is less than that of buying plants, availability of plants can be regulated, and entry of disease organisms from outside sources can be minimised.

Where large numbers of plants are to be raised it is advisable to construct a special propagating house. These are usually 25ft. or more long, 11ft. wide, and 7ft. high with side walls 5ft. high. Walls are constructed mainly of asbestos sheeting or wood, with 24in. of

glass under the eaves. Wooden benches to accommodate the plant trays are 30in. high and 3ft. 9in. wide and run the full length of both sides of the house, leaving a pathway 3ft. 6in. wide down the centre. Ventilation is provided by wooden sash ventilators 4ft. long by 1ft. 6in. wide spaced alternately on either side of the ridge and 8ft. apart on each side.

If possible the propagating house should run east and west, as plants raised in winter will then have full advantage of the reduced light at that time of year.

Propagation houses should be thoroughly cleaned and disinfected and all seedling boxes should be similarly treated.

Only a general recommendation can be made about soil for seed boxes, but certain principles must be observed. Too rich a soil is not advisable, but it should be sufficiently open in texture to induce rapid root growth and yet be sufficiently retentive of moisture to avoid rapid drying out. It should also be steam disinfected or treated with a reliable soil disinfectant.

Generally any average topsoil, preferably from a pasture or from a field that has not grown tomatoes, is satisfactory. To every 5 parts of soil 1 part of well-rotted stable manure or compost and a sprinkling of carbonate of lime should be added and the whole mixed thoroughly. The John Innes Horticultural Institution, however, recommends the use of a standard compost made of 2 parts of medium loam, 1 part of good peat, and 1 part of coarse sand. To every cubic yard of this compost 2lb. of superphosphate and 1lb. of carbonate of lime should be added. The loam should be disinfected before the compost is mixed.

Seed Saving

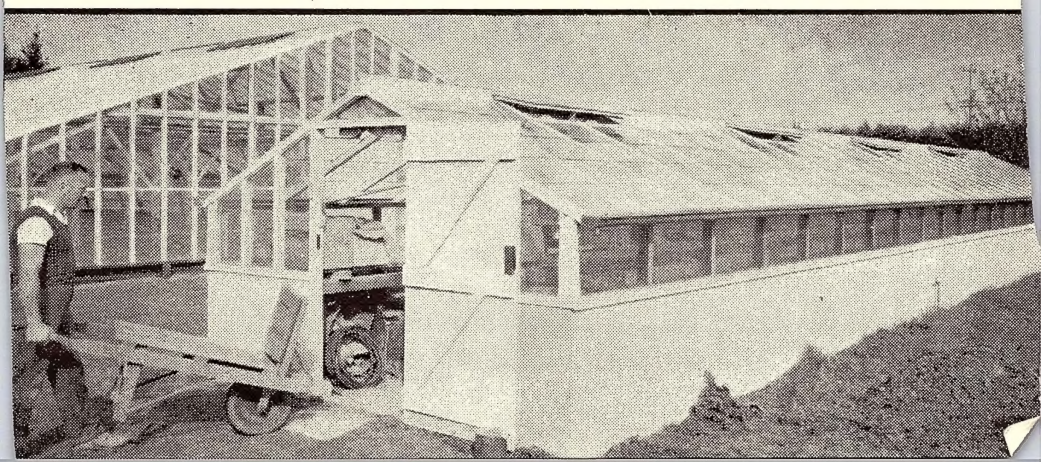
Only the best seed should be purchased, as the extra expense for good seed is a relatively small item. Many growers prefer to save their own seed by selecting the best fruits from carefully chosen, vigorous plants carrying heavy, disease-free crops. When suitable plants have been selected fruit from the first two trusses may be harvested and marketed. The remaining fruit should be left to ripen fully on the plants, when the final selection may be made.

Extraction of Seed

As several serious diseases are commonly carried with the seed of tomatoes, seed extraction should be by the following method, which will eliminate infection:—

Acid extraction: The fruit is weighed and the pulp then squeezed into a wooden container. Commercial hydrochloric acid (1 fl. oz. of acid for each 5lb. of fruit) is stirred into the pulp with a wooden stick. Occasional stirrings are given during the next 3 hours. The seed may

A propagating house large enough to accommodate 8000 plants. Ventilation is provided by sashes on each side of the roof. The rafters, spaced 24in. apart, allow plenty of light to enter. The wide doorway and pathway down the centre of the house are a convenient size for the plant trays to be taken in and out on a wheelbarrow.



then be placed in a fine sieve or muslin bag, washed under running water, and set out to dry in the sun. Acid extraction is fast and not only eliminates seed-borne diseases, but gives a bright seed sample with high germination.

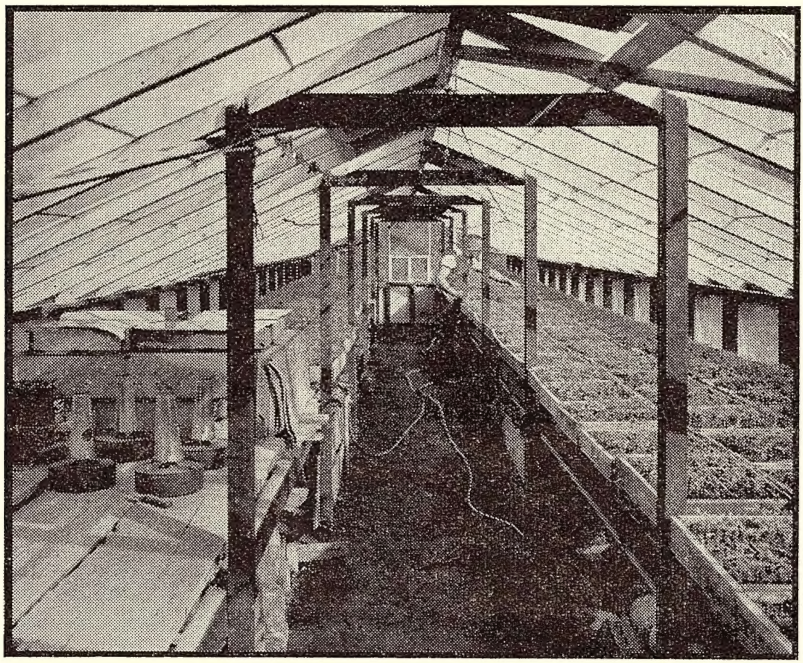
Seed treatment with acidulated mercuric chloride: When seed of unknown origin is used it should be soaked for 5 minutes in acidulated mercuric chloride solution (1 gm. of mercuric chloride dissolved in 2.5 c.c. of concentrated hydrochloric acid added to 2000 c.c. of water). After treatment seed should be dipped in skimmed milk and dried thoroughly before being sown.

Seed Sowing

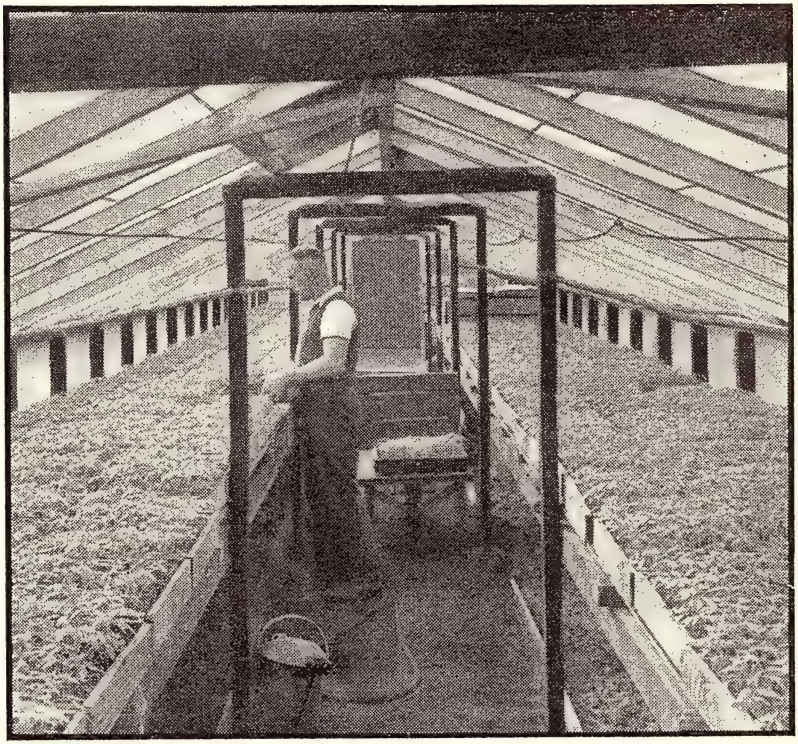
An ounce of seed should produce from 5000 to 6000 plants. Seed is sown in seed boxes which for convenience should be of a standard size (16½in. x 12in. inside measurement) and accommodate 35 plants (5 across and 7 lengthwise).

The prepared soil is passed through a ½in. sieve, the boxes are filled, and the soil is pressed down to within about ½in. of the top, any fibrous material caught in the sieve being placed in the bottoms of the boxes. The soil should be firmed evenly, particular attention being paid to the corners. If the soil is very dry, it should be watered before the seed is sown.

The number of seeds planted in each box varies considerably. Some growers prefer to sow the seed thickly (about 400 seeds). This method is satisfactory provided the plants are pricked off later into another seedling box or pot before the true-leaf stage. When sown too thickly plants are more likely to become drawn and spindly and are



Interior of propagating house, showing small plants and boxes covered with paper and glass (extreme left) in which seed is being germinated. The small kerosene lamps in the left foreground are lit on cold nights and placed at regular intervals along the centre pathway to give protection from frost.



Plants being removed from propagating house for setting out in glasshouse.

more difficult to handle when pricking out. Seed should be scattered evenly and thinly and covered with a light layer of finely sifted, sandy soil. Boxes should be watered through a fine rose and covered with glass with a sheet of paper on top. Seedlings should appear in from 7 to 10 days, when the covering should be removed. The optimum temperature range for germination and growth of tomato seedlings is from 60 to 65 degrees F.

Boxes for pricking out are prepared similarly to seed boxes and the soil is watered so that it is moist but not too wet. The seedlings should be handled carefully by the leaves and placed in the soil almost up to the seed leaves, about 2½in. each way being allowed between plants. Soil should be firmed gently against the roots with a small wooden dibble. If the weather is bright, the newly set out plants may need shading for the first day. Watering may be done the following day, but a fine rose should be used. Further waterings should be limited to just sufficient to keep the plants growing, as a relatively dry atmosphere will greatly reduce danger of frost injury and the risk of infection by fungous diseases.

Later when seedlings are in the plant stage the temperature of the houses should be regulated according to the weather. This does not mean that the temperature must be changed every few hours, but that during dull weather the temperature should be lower; too high a temperature during dull weather will cause the plants to become drawn and spindly. Ventilation may be given on the lee side of the roof, but not to excess. The plants

must be protected from draughts, which can result from badly designed ventilation systems.

Watering should be done sparingly through a fine rose (enough only to keep the plants growing). Too much water, especially in cold weather, will chill the plant roots and make conditions favourable for root rot and damping-off fungi.

It is important to grow good plants. They should be about 6in. high, stocky, dark green, and have an abundance of white roots. The appearance of the seed leaves is a good guide to a healthy plant. These should be green and turgid. Damage to the roots during pricking out or excessive wetness and coldness of the soil will encourage root rot organisms. The injured tissues are attacked by bacteria and fungi which are not so likely to attack healthy roots growing in soil that is suitably warm and aerated. If plants with root decay are set out in the house, it is most unlikely that a good crop will result, because the rot spreads slowly upward and usually causes trouble at some stage in the life of plants.

Overcrowding of the plants in the propagating house is not advisable, and before this occurs they should be removed to the glasshouse and left there with the boxes well separated until planting out time.

Some growers prefer to grow their plants in pots or plant frames (small, bottomless wooden containers). These are filled with the soil mixture used for seedling boxes and one plant is set direct from the seedling box into each container. This method has many advantages, the main one being that the plant roots have more room for development and are not unduly disturbed when being planted in the house. Consequently they establish more quickly and give a more uniform stand than plants taken from trays. The use of soil blocks is gaining popularity for the same reason. There is now a special tool on the market for making these soil blocks. The essential point is to use a good moisture-retentive compost.

Dates of sowing and planting: As these depend mainly on the prevailing weather, which varies so much in different localities, no definite time can be given. Generally plants are ready for planting out in the house about 6 weeks from the sowing of the seed, which should be timed to suit local conditions.

In the North Island, except for a few colder localities, heated houses are planted in May and June to produce a crop from September to December and most of the unheated houses in June and July for harvest from October to January. In the northern parts of the North Island, from Hamilton northward, a number of late plantings are made in the last week of February for production throughout winter, and the majority of these are in unheated houses. The majority of glasshouses in the South Island, except Nelson, are heated and planting is usually done in heated houses from June to August. In unheated houses planting is done in August and September for harvesting from November to the end of February.

Although very early plantings are favoured by some growers of glasshouse tomatoes, these crops do not usually yield heavily, and are more or less a gamble and are deemed economic only because of the high prices obtained for early fruits.

[Photographs on cover and pages 7, 8, and 9 by Sparrow.]

Soil Preparation for Planting, Disinfection of Soil, Planting, Watering

IF new glasshouses are to be erected on ground already in grass, it is best for this to be done without the turf being disturbed. If turf is worked up before building begins, the physical condition of the soil may be injured by continual tramping of it during building. It is advisable to cover the surface of cultivated land with straw, which can be worked into the soil when building is finished.

Manuring

The addition of 25 tons per acre (12lb. per square yard) of well-rotted animal manure or compost will ensure that the soil contains sufficient humus. In addition a basic dressing of 4 parts of serpentine superphosphate, 6 parts of bonedust, and 1 part of sulphate of potash should be applied at 2oz. to the square foot. For each 1000 sq. ft. the amounts required are 45lb. of serpentine superphosphate, 67½lb. of bonedust, and 12½lb. of sulphate of potash, a total of 125lb.

For houses that have been cropped for 2 years or more the amounts in the above manurial programme may be halved if there has been a build-up of fertilisers in the soil.

Cultivation

Preliminary: The fertiliser should be well worked into the top 6in. of soil, preferably by rotary hoe.

Trenching: Double digging or trenching the soil to make it uniform to a depth of 12in. or more assists in preventing later trouble due to irregularities in soil depth and physical composition. During digging it may be necessary to loosen the subsoil.

It is a well-established fact that a deep, rich soil produces better tomato crops than shallow soils and it is of the greatest importance to see that the subsoil is in a suitable physical state for root development. Hard, closely compacted, cold subsoils or those that are too dry will not encourage favourable root development. The importance of this point cannot be over-estimated, as there is a tendency to rely on manurial treatment as the answer to all soil problems.

Occasionally, however, the recommendations on soil working do not apply, and in old-established glasshouses the type of digging will depend on the nature of the soil. Generally, the more the soil is worked the better its condition will be, and although heavy soils should be trenched every year if possible, lighter soils that have been cultivated for 3 years or more will probably give as good a result if trenched only every third year.

Mechanical cultivators of the rotary type are now used widely in glasshouses to chop up green crops, to aerate the soil after chemical disinfection, and to incorporate the base manurial dressing into the top 6in. of soil before trenching. A machine that will dispense with hand trenching has not yet been designed.

The correct way to trench is to divide the house into two equal parts, the central path being the dividing line. A trench 12in. deep and 18in. wide is opened against one of the end walls (say, the west) across one half of the width of the house (from the central path to the outside wall). The soil from this trench is laid on the path, the top 6in. spit being kept separate from the lower 6in. The bottom of the trench is then loosened up by forcing a garden fork into the subsoil and drawing the handle backward toward the operator.

To ensure an adequate supply of moisture in the subsoil the trench should be flooded with water. A fairly light soil or gravel subsoil may need flooding several times, but heavy soils should require only one flooding. To improve drainage the bottom and face of the trench should be covered with well-weathered straw.

The next spit is then turned into a trench, the top 6in. containing the manure going to the bottom of the trench and the lower layer without manure being placed on the surface.

A diagram of the profile of a soil to be trenched is given on page 12.

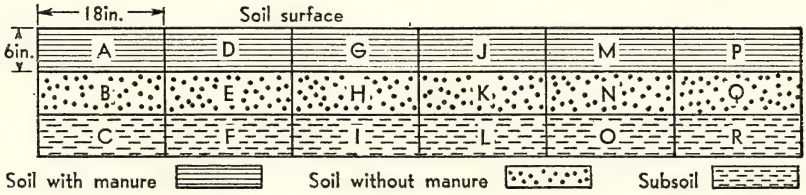


Diagram of the profile of a soil to be trenched.

Spits A and B are removed to form the first trench and are placed separately aside. C is then forked up as described. After the trench has been watered and the straw placed in it D is dug and placed over C and E over D. F is then forked, the trench is prepared, and G is placed over F and this routine is repeated until Q is placed in the position formerly occupied by M, leaving a trench above R at the east end of the house. This trench is filled by the soil from a trench dug on the other side of the pathway against the east wall, similar to the first trench opened against the west wall. The second side of the house is then trenched in the same manner, working back toward the west wall, the final trench being filled by the soil originally placed on the path from spits A and B.

Liming

The lime content of glasshouse soils is important. Lime is necessary to neutralise soil acidity, to release certain plant foods, and to improve the physical structure of the soil. The most generally used form of lime and the one suited for most soils is carbonate of lime. The annual requirement of most glasshouse soils is about ¼lb. to ½lb. a square yard according to the soil pH, but where doubt exists growers should consult the Horticultural Instructor for their district about the appropriate dressing.

A rate of ¼lb. a square yard requires ½cwt. of lime to each 1000 sq. ft. To produce the maximum effect the lime should be sown on the soil surface after trenching and a sprinkler should be used to ensure that it is carried into the soil. The top 12in. should be thoroughly moistened. After the soil has been watered all doors and ventilators should be closed for about 2 weeks to enable the soil temperature to rise and hasten the decomposition of the organic matter.

Disinfection of Soil

To control soil-borne pests and diseases which, if left uncontrolled, would adversely affect the yield of the plants, several methods of treatment are commonly used. These include steam, chloropicrin, chloropicrin + D.D., and formalin. These soil treatments must be carried out before the plants are set, as later applications would cause injury to plants.

To be assured of good penetration of steam or chemicals through the soil it is essential that the soil should be finely cultivated to a depth of at least 12in. and that all strawy material in the soil should be well rotted. The moisture content of the soil must also be correct. To check this a sample of soil should be taken from a depth of 4in. and the soil when compressed in the palm of the hand should retain its shape. If it crumbles, it is too dry; if water exudes, it is too wet.

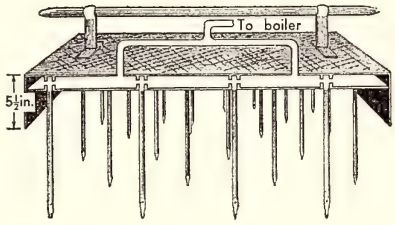
Soil temperatures for steam heating should be above 50 degrees F. and for chemicals not less than 55 degrees. When the soil is treated with chemicals which are toxic to plants it is necessary to fork it up to break the crust several days after treatment to allow the fumigant to escape. Wet or cold soils will retain the residual gases for much longer than warmer soils.

Steam Disinfection

When glasshouse soil is treated with steam it is generally necessary to have a boiler of 20 to 25 h.p. However, the capacity of the boiler depends largely on how far the steam has to be taken. It is essential to have a boiler large enough to supply a continuous head

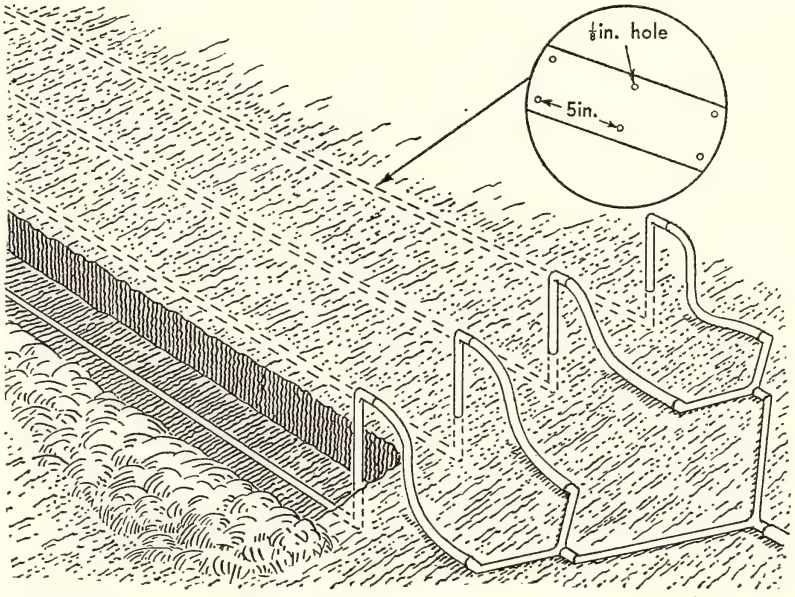
of steam through a 1½in. pipe at a pressure of 80 to 90lb. a square inch. The following are methods of applying steam disinfection:—

Steam harrow: This equipment is used most commonly. It consists of a steam chamber 2ft. 8in. square and 1½in. deep of galvanised iron with 13in. long tines attached (see diagram at right). The tines are of 3-8in. hollow piping with pointed ends and are arranged in 6 rows of 7. The harrows are usually operated in pairs to allow one to be shifted to a new area while the other is operating, thus saving any loss of time for the operator. The steam coming out of the ends of the spikes is retained in the soil by a tray until the soil has been subjected to a temperature of 180 degrees F. for 10 to 15 minutes. The harrow is then moved to an adjacent area and the area just treated is covered with sacks. Although this method is fairly satisfactory, it sometimes leaves untreated portions of soil near obstructions such as support posts and the steam does not penetrate the soil to a depth of more than 12 to 18in. Treated soil is readily recontaminated by disease organisms from any untreated areas.



Cross-section of harrow or grid commonly used for steam disinfection of soil.

Hoddesdon pipe system: The following information on this system has been extracted from "Tomato Diseases and Pests in New Zealand and Their Control" by J. D. Atkinson, R. M. Brien, E. E. Chamberlain, W. Cottier, H. Jacks, W. D. Reid, and G. G. Taylor of the Plant



Hoddesdon pipe system of steam disinfection. Inset—System of holes in the underground pipes.

Diseases Division, Department of Scientific and Industrial Research, Auckland:—

"A newer method [of steam sterilisation] is the Hoddesdon pipe system, which allows the heating of the entire volume of soil without handicap from obstructions. This system consists of a number of pipes of 1¼in. internal diameter cut to desired lengths. One end of each pipe is closed with an iron plug; the other is fitted with an elbow and connected with a vertical pipe 2ft. long. The horizontal pipe is provided with two lines of 1-8in. holes at 5in. intervals drilled one on each side of the pipe and slightly toward the bottom. The shorter lengths of pipe stand up vertically in the soil during steaming and the top of the vertical pipe is fitted with an elbow and thread for hose coupling. Four of these pipes are joined by a connection consisting of three V pieces of 1¼in. tubing joined together by Y unions. Steam from the main hose enters the connection at the base of the first V, passes along the two arms to two other V pieces, follows the two respective arms, and passes through four lengths of flexible hose, which in turn are connected with the four vertical pipes.

"This arrangement provides an even distribution of steam through the pipes. This method is applied in the following manner: A trench 18in. deep is dug along one side of the area to be treated and the spoil is removed to the other side. The bottom of the trench should be loosened with a fork to facilitate penetration of heat. The first pipe is placed close to the wall, the next parallel to it 20in. away. A second trench is dug, the spoil filling the first, and the same procedure is continued until four pipes 20in. apart are laid in position and covered. The surface is now covered with sacks and four pipes are connected with the steam hose. Another lot of four pipes is placed in position while steam is passed through the first four pipes. The operation is continued by pulling back the pipes into successive trenches dug behind them. Each steaming covers an area of an approximate width of 7ft. by the length of pipes and a sterilising temperature is obtained to a depth of at least 2ft. The time necessary for steaming varies with the soil type and moisture content, but 15 to 25 minutes are sufficient to raise the temperature to 200 degrees F. and above. In this system the digging of soil is carried out simultaneously with steaming.

"This method is suitable for all types of glasshouses, as the length of pipes can be altered to fit particular conditions. The pipes are easily removed, as they only need to be pulled back, and tramping on sterilised soil by workmen is therefore avoided".

Treatment of plant trays with steam: Plant boxes for the growing of plants should also be treated. They should be placed over the harrow or a steam pipe and the whole covered with a tarpaulin and subjected for 20 minutes to a temperature of 200 degrees F. Boxes so treated should be protected from reinfection when stored.

Chemical Disinfection

Although heat treatment is the best method of disinfection and the only one advised for the control of tobacco mosaic diseases, it is costly and as an alternative certain chemical disinfectants can be used satisfactorily to combat diseases other than tobacco mosaic. The best of these chemical methods are:—

Formalin: Commercial formalin (40 per cent. formaldehyde) is diluted with 49 times its volume of water and applied to the soil at 50 gallons per 15 sq. yds. To ensure efficient penetration the soil should previously have been brought to a fine tilth and be just sufficiently moist that when a handful is compressed it will retain its shape without soiling the hands. It is usual to take out a trench at one end of the house and water the sides and bottom with the necessary amount of formalin solution. The next spit is then turned into the trench, this soil and the sides and bottom of the new trench are watered, and so on throughout the area. Covering the soil with damp sacks for 48 hours after treatment will increase the effectiveness of the formalin. After 48 hours treated soil may be dug over to allow the fumes to escape; planting should not be carried out while any trace of formalin remains; otherwise seedlings may be damaged. It is usual to allow 3 to 4 weeks for complete aeration. Potting or seed box soil may be

treated similarly, each 9in. to 12in. layer being soaked before the next is placed on top, and the whole covered with wet sacks. If the soil is in trays, it is usual to set out a row, water with the solution at approximately 5 pints per cubic foot of soil (roughly 2 pints per seed tray), place another row on top, water these, and so on up to a convenient height. The stack is then covered with wet sacks or tarpaulin for 48 hours, after which the trays may be spread out to allow the fumes to escape.

Sowing or pricking out should be delayed until no smell of formalin is noticeable, usually after 2 to 3 weeks. Once the soil has been treated care should be taken to see that it is not reinfected from untreated soil, trays, etc.

Formalin controls fungous diseases effectively, but even at strengths greater than 1 in 50 it gives only partial control of eelworms. However, it delays their activity sufficiently to improve plant growth. A disadvantage of formalin is that the drenching of the soil tends to alter the physical structure, and extra cultivation is required to restore the tilth.

Chloropicrin acts both as a fungicide and an insecticide, appears to improve plant growth, and gives partial control of weeds. It is best applied with a special injector by which the depth and the dose can be regulated, but a dibble and a graduated burette can be used for a small area. The dose and the depth are varied according to the type of soil, heavy soils requiring a greater dose at less depth than light soils. The ground should be well worked, free from lumps, and slightly damp before treatment; wetting of the top ½in. of soil before chloropicrin is used will reduce the unpleasant effect of the fumes. The area is marked out with lines drawn in the soil. The distance between the lines may vary from 10½in. to 1ft., according to the type of injector used. Two to 6 millimetres (1-15 to 1-6 fl. oz.) of chloropicrin is injected at a depth of 4in. to 8in. every 10½in. or 1ft. along the lines, the first injection being made 6in. in from one edge of the house. The holes should be closed immediately to prevent the gas escaping. A further watering at 1 to 1½ gallons per square yard is recommended to seal the surface. Ventilators and doors should be open during treatment, but immediately after they should be closed and the soil left undisturbed for 48 hours. The area can then be forked over to aerate it and should be ready for planting in 2 to 3 weeks.

Chloropicrin is not satisfactory for soil in trays, but loose soil can be treated in drums, barrels, or boxes. The disinfectant is injected at varying depths to ensure thorough penetration and the containers are covered with wet sacks or tarpaulins for 48 hours, after which the soil should be thoroughly aerated before use. The rate of application varies with the type of soil; 3 millilitres per cubic foot should be allowed for composted soil, 5 millilitres for ordinary soil, and 10 millilitres for clay loam. The gas will permeate the soil 5 to 8in.; the number and spacing of injections should be calculated on this basis.

Killing of weed seeds is improved if the soil has been watered about a fortnight before chloropicrin is injected and kept at a suitable temperature to encourage germination.

Chloropicrin should be stored in a cool place, preferably in glass or thick metal containers. As it decomposes cork and rubber stoppers, metal or plastic tops should be used. It is not inflammable, either in the liquid or gaseous form. If chloropicrin is spilt on the skin, it should be rinsed off with soap and water, because it can cause inflammation. It is advisable to use a gas mask when filling the injector or when treating the soil, as chloropicrin causes smarting and watering of the eyes, and when inhaled, violent coughing.

A pound of chloropicrin is sufficient to treat 90 sq. ft. at a rate of 3 millilitres per injection. A level teaspoon contains 5 millilitres.

D.D.: This fumigant is economical to use and will control eelworm and soil-borne pests. It is also useful against damping-off and wilt diseases and will kill a fair percentage of weeds. Methods of application for potting soils and soils in situ are the same as described for chloropicrin. After treatment 4 to 6 weeks should be allowed before plants are set out, as this fumigant remains in the soil longer than

House prepared for planting, showing how plant beds are formed. The support posts are in the centres of the plant beds with two pathways between the support posts.

chloropicrin, especially in heavy soil. It is less volatile and requires no water seal after the soil treatment.

For more comprehensive information on disinfection of soils see Department of Agriculture Bulletin No. 363, "Disinfection of Nursery Soil".

Levelling and Marking

Levelling is essential for even distribution of moisture and ease of planting. The soil in each bay should be levelled separately, a bay being the area between two support posts and the central path and outside wall, roughly 8ft. x 14ft., but varying with the size of house. A piece of 4in x 2in. timber (straight edge) with spirit level attached and long enough to reach from the path to the wall is laid level down the middle of the bay and the soil raked level by eye judgment on each side. Each bay is levelled in turn.

Marking: Measurements depend on distance between support posts (see the table in the section on plant and row spacings on page 5). If posts are 8ft. apart, the plant support wires are 18in. apart with 30in. between pairs of wires. The support posts should be midway between the 18in. spaces so that they do not block the lateral paths.

A 2ft. 6in. pathway is left down the centre of the house and the area on each side is marked with lines 24in. apart at right angles to the pathway. Alternate 24in. spaces should correspond with the pairs of overhead wires. The soil from alternate spaces is scooped out with a flat-mouthed shovel to make wide trenches 3in. to 4in. deep and the spoil is spread evenly on the intervening spaces. This operation forms plant beds and paths, the paths being raised slightly above the beds. The centre path is raised to the same level as the lateral paths.

The beds are then marked out for planting. The planting lines should run parallel down each plant bed 18in. apart and 3in. in from the

edges, bringing the lines directly below the wires. The plant holes are made along these lines 12 to 15in. apart, the first hole 6in. in from the central path.

Plant holes are sometimes made with a dibble consisting of an iron bar with a mould at one end and handle at the other. This is thrust into the ground, given a half turn to left and right, and withdrawn, leaving a clean hole.

Planting

The plants are removed from the boxes, which should have been well watered 12 hours previously. Each plant is carefully taken out by hand with the soil adhering to the roots and placed with as little disturbance of this soil as possible into a prepared hole. The soil is then firmed around it.

In this operation plant roots should be damaged as little as possible, as damage to roots will facilitate the entry of harmful fungi. The old method of cutting plants out of seedling boxes with a knife or trowel is seldom practised.

Water should not be applied at planting. If the soil has dried out, watering should be carried out a few days before planting to avoid the possible reduction of soil temperature. If, however, the soil has been steam sterilised and consequently is still very warm, water can be applied if necessary without causing unfavourable results.

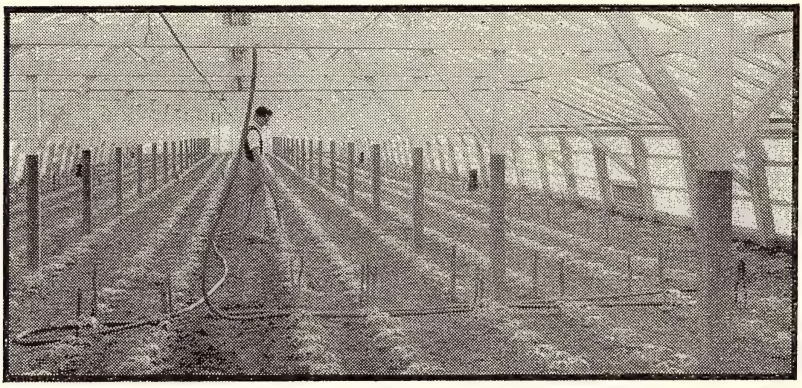
To ensure good development of plants after they have been set out temperature should be maintained at between 70 and 75 degrees F. In an unheated house it is not always possible to achieve this range, but the difference between day and night temperatures should be kept to a minimum. Temperature fluctuations of more than 10 degrees are not favourable for best plant development.

Watering

During the first 3 weeks after setting out, plants will require very little watering and any water given should be directed into the shallow depression round each plant and so straight on to the balls of the roots. When plants become well established and the roots extend normal watering may begin. Times between watering will depend on the texture of the soil. Too little water may cause the flowers to drop and later may make the plants poor and weak. Over-watering encourages root rots and soft growth, which are

House in the illustration on the opposite page 3 weeks after planting, showing plants set out in double rows 18in. apart with plants 1ft. apart. The pathways are 2ft. wide and the plants are set 3in. in from the edges of the pathways. The stakes at the end of each double row prevent the hose from damaging plants when watering is being done.

Above—Unheated glasshouse which runs east and west. Plants are set in single rows across the house. Rows are 27in. apart and plants 12in. apart. Plants are being tied to support wires. The stakes at the ends of rows protect plants from damage by the hose during watering. Plants were set out on the flat and the soil was ridged up to them later. Below—Unheated glasshouse which runs north and south; therefore plant rows run lengthwise. Support posts are between plant rows and do not obstruct pathways. With this method of planting the main paths run lengthwise of the house, and to facilitate working several pathways are also left at intervals across the house. Short stakes are placed on each side of these cross-paths, one at each end of plant rows, to guide the hose and keep it from damaging the plants during watering. Plants are set out on the flat in double rows 18in apart and are spaced 15in. apart. There is 33in. between each set of double rows. Kerosene heaters on each side of the house are used on cold nights as a protection against frost. They are spaced at regular intervals 3ft. in from the walls, one heater to about 500 sq. ft.



particularly dangerous when plants are young; hence great care is necessary with early watering. On very light soils, which tend to dry out quickly, a mulch of straw or strawy manure given when the first truss begins to ripen will reduce surface evaporation and hence the amount of water required.

It is difficult to judge the exact day to begin the main watering; if water is applied too soon, growth will be too succulent, but if it is delayed too long, setting of the flowers may be adversely affected. Generally, watering can be done with reasonable safety if delayed until the flowers on the second truss have set, as then the swelling of the fruit will help to counteract the softening effect of watering. Where plants are set out later in the season or for autumn crops it will be necessary to water at an earlier stage of growth.

The condition of the flowers is a clear indication of the plant's moisture requirements; if these are robust and a good, bright yellow and the truss stalk is dark green and turgid, water is not needed. If, on the other hand, the flowers are dull and pale and the stalks grey, water is necessary. If the flowers are falling off, water is needed urgently, but experienced growers seldom allow plants to reach this stage.

To ensure that plants are receiving adequate water the soil should be examined frequently. A sample of soil taken from a depth below 4in. should be squeezed in the palm of the hand; if water is exuded, the soil is too wet and if on release the soil crumbles, it is too dry. The moisture content is correct when the soil retains its shape after being pressed.

If water is required, it should be given in sufficient quantity to wet the soil to a depth of at least 1ft. and is best delivered by large-diameter hose at low pressure. If the delivery is fierce and is likely to wash the soil, a "sock" (a piece of material that will allow water to flow freely through it) should be tied to the end of the hose. To prevent damage to plants when the hose is being moved during watering short stakes are placed on each side of the centre pathway, one at the end of each row (see the illustrations on pages 17 and 18).

Watering should make the soil uniformly moist. The hose should be kept close to the ground to avoid splashing the plants. Whenever possible watering should be done in the mornings to give the soil time to warm up again before nightfall.

[Photographs on pages 16, 17, and 18 by Sparrow.]

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Pruning and Training, Ventilation, Cultivation, Fertiliser Side Dressings

PLANTS are trained to a single stem and all laterals arising from the leaf axils are removed, the first about 3 weeks after planting. If these axillary shoots are allowed to develop too much, removal of them leaves large wounds, through which disease organisms can gain entry, and plant energy is wasted.

Removal of laterals is discontinued when plants reach the support wires, and when they have grown up to three leaves above these wires the terminal buds are removed and plants are allowed to spread out on top of the wires to form canopies, which shade the fruit and soil.

When plants are about 1ft. high the two lowest leaves are removed and below the third leaf a length of binder twine is tied with a reef knot. The loops of these knots should be large enough to allow plant stems to swell. The top ends of the twine are tied to the wires immediately overhead with bow knots, a slight sag being left in each length of twine between the plant and the wire. As plants grow the twine is twisted anti-clockwise around them to give support and this operation finally takes up the slackness in the twine.

When the fruit in the first trusses has grown to the size of a marble all the leaves below this should be removed by snapping them off at the bases of the leaf stems. This enables air to circulate more freely around the bases of the plants, facilitates cultivation and side dressing, and makes conditions less favourable for leaf mould infection, which usually begins on the lower leaves.

Damping

In heated houses light overhead damping daily with a fine syringe after planting out will reduce the amount of water required at the roots and reduce sappy growth induced by too much watering. As the weather becomes warmer more than one damping may be necessary, but it should be done not later than the early afternoon, because late damping leaves the plants wet and chilled for the night and predisposes them to infection by botrytis and leaf mould.

Unheated houses also require overhead damping on warm days, but it should never be done on cold, damp days. If damping is not practiced, the atmosphere is likely to become too dry for natural pollination and the fruit does not swell properly.

Pollination is also aided by gently tapping the overhead wires during the middle of the day, which will cause the pollen to fly.

Fruit Setting with Hormones

It is no longer absolutely necessary to damp down the flowers or to tap the wires to aid setting. Instead trusses of flowers can be sprayed as they open with a suitable proprietary fruit-setting hormone at the strength recommended by the makers. This should be directed into the truss with an atomiser when the flowers are fully opened and bright yellow. Within a few days, often before the flowers have withered, the small fruits begin to swell. They develop steadily and are the same in colour and appearance as fruit set naturally except that they may have fewer seeds.

Although hormone sprays are best used on the open flowers from the start, they can also be used successfully to counter dry set (failure of the fruit to swell), provided they are applied shortly after the flowers have fallen.

Reasonable care should be taken to direct the spray away from the top of the plant, because young, actively growing shoots may be injured by the hormone. Equal care must be taken to wet all the truss thoroughly. The liquid must touch the base of the flower and wet the hairy calyx region.

Any flowers that have withered before the application is made should be removed carefully to allow the small fruit at the base to receive the hormone.

Plants with first trusses of fruit nearing maturity, showing how support strings are attached and bottom leaves removed. Straw is used at this stage as a mulch and is spread over all the soil surfaces including pathways.

When some proprietary hormone preparations are mixed the hormone must be added to the water, because if the water is added to the hormone, it will cause it to froth and it cannot then be atomised and used efficiently.

Although it is not usually necessary to use hormone sprays on more than the first and second trusses, spraying later-developed trusses will ensure a complete set of fruit on each and the yield per plant may be increased considerably.

Temperature and Ventilation

In glasshouses day temperatures ranging from 70 degrees on dull days to 85 degrees on bright, sunny days, and night temperatures of 60 degrees to 65 degrees are satisfactory for tomatoes. Sudden fluctuations or very low or very high temperatures are very injurious to the crop.

Success in the growing of a tomato crop under glass is to a great extent influenced by the use of suitable houses capable of being maintained at a favourable temperature under all weather conditions. Ventilation is extremely important. Some circulation of fresh air to all plants is important even during cold weather, and this must be given without exposing then to draughts. Houses with ventilators under the eaves the full length of both sides of the house and with ridge ventilators along the full length and on both sides of the ridge come nearest to meeting optimum requirements.

After the plants are set care must be taken in ventilating. To give the plants fresh air some ventilation will be necessary during the day and this should be governed by the weather outside. The usual practice of opening the ventilators at 8 a.m. and closing them in the evening cannot always be adhered to. With unheated houses in the early part of the season it is very important that any warmth derived from sunshine during the day should be retained for as long as possible during the night and this can be done only by closing the

ventilators in the early afternoon. The minimum temperature prevailing during the night can be read off a suitable thermometer the next day. If this reading is very low and the house was closed the previous day at 4 p.m., the owner should try closing the ventilators at 3.30 p.m. It is only by familiarising one's self with prevailing house temperatures that efficient ventilation likely to give the greatest benefit to the plants can be attained.

Cultivation

Hand hoeing is necessary to suppress weeds, to aerate the soil around plants, and to maintain a fine tilth.

Cultivation should be shallow to avoid injuring any plant roots growing close to the surface. It is usually done after watering to prevent caking of the surface soil.

Side Dressings

It is difficult to generalise about side dressings, as treatment depends to some extent on the condition of the soil. It is wise to consider the effect of different kinds of fertilisers.

Nitrogen induces darker and more luxuriant foliage and rapid growth. Its effect on the tomato depends to some extent on the conditions under which plants are grown. Softness of tissue, large leaves, and rapid growth are induced when the soil is damp and the atmosphere hot and humid. A shortage of nitrogen in the soil usually produces pale, thin plants with rapidly maturing fruit. A yellowing of the leaf tissue between the veins may develop and later the leaves may go yellow throughout. Growth at the top of the plant may become pale and weak, flowers fail to set, and top trusses fail to develop.

Phosphorus: The effect of phosphorus (usually applied as phosphate) is to increase root development and hasten fruit maturity.

Potassium: Potassium (usually applied as sulphate or muriate of potash) induces a firm, mature type of growth and helps the plant in its resistance to disease. It is essential for good colour and quality of the fruit. Too much potash, however, gives a very hard type of growth, with small, dark leaves, and small, hard fruits.

A shortage of potash may cause blotchy ripening of the fruit and produces maginal leaf scorching with a yellowing and browning which spreads finally toward the centre of the leaf until little green is left.

When young the tomato plant requires a considerable quantity of potash and only small amounts of nitrogen. As it increases in size the applications of potash should be decreased and those of nitrogen increased. Tomato plants require much more potash than nitrogen during prolonged spells of dull, wet weather and the opposite in fine, sunny weather.

Suitable Food at Correct Time

Success in the use of side dressings depends on applying a suitable food at the correct time. The amounts of the different types of fertilisers have to be governed to some extent from observation by the grower of the appearance of the plants and fruit.

The side dressings generally used for early applications contain equal parts of dried blood and superphosphate and about 4 per cent. of sulphate of potash. For an application of 1oz. per plant to 1000 plants the following quantities are required:—

	lb.
Dried blood	30
Superphosphate	30
Sulphate of potash ..	2½
	62½

Some growers use proprietary fertiliser mixtures conforming approximately to the above proportions, but mixtures used should vary to some extent according to particular soil requirements.

For later applications, when phosphate and potash are not required by the plants to the same extent, a nitrogenous fertiliser (dried blood, nitrate of soda, or sulphate of ammonia) is used at the rate of ½oz. to 1oz. per plant.

Side dressings should be applied as often as required. Frequently this is at intervals of 21 days, beginning usually when the second truss is in the flowering stage. The fertiliser should be spread evenly around the plants and watered in, care being taken to keep the fertiliser off the stems and foliage.

Mulching

Mulching of the house with straw or strawy stable manure is commonly practised. The material is spread over all the soil surface as soon as the fruits on the first truss are showing signs of ripening. If it is put down earlier, it may prevent the soil from warming up quickly. Mulching makes the soil surface clean for walking on and helps to conserve moisture and to keep down humidity. Worked into the soil later the material helps to build up the humus content of the soil.

Harvesting

THE fruit is picked by breaking it away carefully from the truss at the joint nearest the calyx. Fruit is generally marketed without the calyx, which can be removed easily by rubbing it off with the thumb.

The stage of ripeness at which the fruit is picked is governed mainly by distance from markets. For local markets a good red is preferred; for longer transport the fruit must be harvested as soon as the slightest colour shows. Fruit should not be picked when it is too green, because this impairs its eating quality later and in green fruit it is not easy to detect faulty coloration. The fruit is usually picked into containers made from halved kerosene tins and these when filled are loaded on to a small trailer and transported to the packing shed.

Most large units have a tomato-sizing machine powered by an electric motor in the packing shed. When a machine of this type is used the fruit is emptied from the buckets into the hopper, where an operator directs it down a small chute to the revolving rollers, at the same time rejecting any blemished or misshapen fruit. As the fruit

Packing tomatoes from a double-sided electrically powered fruit-sizing machine.

passes along the felt-covered rollers spray residues are removed and it is separated according to size into different bins situated directly below. The fruit is then packed by hand into standard cases, which are set out in the New Zealand Grown Vegetable Regulations 1952. The specifications of standard packages for tomatoes are set out in the table below.

The grading of tomatoes into various sizes before packing enables a uniform pack to be attained and considerably enhances the appearance of packages in the market.

Most growers aim to pack 20lb. of fruit into cases of types B and D, and to increase the attractiveness it is common practice to line cases with green paper. Suitably designed labels which have the net weight of fruit stamped on one corner are also placed on one end of each case by many growers.

SPECIFICATIONS OF STANDARD PACKAGES FOR TOMATOES

Type of package	Dimensions (inside)			Thickness of timber			
	Depth in.	Width in.	Length in.	Ends in.	Sides in.	Tops in.	Bottoms in.
A	2½-3½	11½	18	$\frac{5}{8}$ or $\frac{3}{4}$	5/16	5/16	5/16
B	7	7	18	$\frac{5}{8}$ or $\frac{3}{4}$	5/16	5/16	5/16
C	6	9	11	½	¼	¼	¼
D	4½	12	16	$\frac{5}{8}$ or $\frac{3}{4}$	5/16	5/16	5/16
E	4½	7	18	$\frac{5}{8}$ or $\frac{3}{4}$	¼	¼	¼
F	4½	7	8¾	½	¼	¼	¼

Spray Outfits

THOUGH a few growers still use knapsnack sprayers, power outfits of two types, portable and stationary, are commonly used. The portable type consists of a petrol engine, pump, and spray container mounted on wheels which enable it to be moved readily from place to place. This type of machine is superior to the knapsack, which is laborious to work and difficult to manoeuvre among plants.

The stationary type is made up of a pump driven by either an electric motor or internal combustion engine and is usually installed in a shed near the glasshouse. The spray mixture is pumped through galvanised pipes from a concrete mixing tank which holds a convenient quantity of spray material, usually from 100 to 500 gallons. The pipelines that carry the spray from the tank to the glasshouse are similar to those which service the glasshouse with water (usually ½in. diameter), or the same pipelines may be used for both purposes. At intervals throughout the house pipelines are fitted with hose taps, to which a length of high-pressure hose with a spray lance and nozzle can be attached. The hose needs to be about 40ft. long and is attached in turn to each tap along the pipeline. The pressures used when spraying are approximately 150lb. to the square inch; too high a pressure is likely to damage foliage or fruit.

[Photographs on pages 22 and 24 by Sparrow.]

Heating

IN districts where heating of tomato houses is practised hot-water heating systems are by far the most popular. Modern units are thermostatically controlled and have automatic stokers or oil firing. However, a few glasshouse boilers are still hand fired, and in some districts glasshouses are heated by portable heaters. For best results the heating system used should be capable of maintaining a uniform temperature, as substantial fluctuations may be harmful to the crop. Reasonable variations between night and day temperatures are not unduly harmful, but too frequent or severe fluctuations should be avoided whenever possible.

Details of the heating systems mainly used are given below:—

Hot-water Systems

With hot-water systems two methods are used to ensure proper circulation of water through the pipes, one being the thermo-siphon or gravity system and the other the forced-circulation system.

Thermo-siphon system: Until a few years ago this was the most common installation used in commercial heated glasshouses. The water circulates through the hot water rising to the highest point of the system and the cool water returning to the lowest point in the boiler. This type of installation is not always satisfactory, because pipes may have to be put at inconvenient heights to ensure that the water circulates. In addition the boiler usually has to be placed below ground level, which has disadvantages, such as inconvenience and liability to flooding. This system is not practicable when houses are more than 150ft. long, because circulation is too slow and the water cools too much before return to the boiler.

Forced-circulation system: For this a small motor pump is fitted at some point in the hot-water system. Water can be circulated much more efficiently than in the thermo-siphon system. The system is claimed to be much more satisfactory, as it gives increased efficiency in fuel usage and certainly enables the pipes to be laid at any convenient height, because water flow does not depend on gravity.

Methods of Water Heating

Sectional boilers are the most common type installed at present, but some tubular boilers are used. Tubular boilers are easier to repair, but sectional boilers probably heat the water more quickly. Both are suitable for glasshouse heating.

A boiler capable of heating up to a third more piping than there is in the system should be installed so that a reserve of heat is available to deal with exceptional weather. Soft water should be used if possible, as hard water causes scale formation, which reduces the efficiency of the boiler and hastens corrosion.

Automatic Stokers

The type of stoker usually used in New Zealand is known as the underfeed type. It feeds small coal into the bottom of the fire by an automatically controlled worm gear. Most automatic stokers are thermostatically controlled and give satisfactory results. It is claimed by some growers that the efficiency of heating and saving in labour more than offset the cost of the extra equipment. The convenience of automatic night firing is a great advantage.

Solid fuels, coal v. coke: Fuel costs are heavy in producing crops in heated houses and therefore the fuel that will be most economical should be selected. Whether coal or coke should be used seems to depend largely on their relative availability. Coke is used by many growers and is considered as satisfactory as coal and cheaper, but it is not always readily available.

Oil v. solid fuel: Growers who have used both solid fuel and oil say that there is little difference in cost. The initial cost of oil is higher, but it costs less to handle, it is cleaner, and it is easier to store. Most oil-fired boilers are thermostatically controlled. An oil furnace requires a compressor, which is usually operated by electricity. This is a disadvantage if a power failure occurs and puts the boiler out of action at a critical time.

Thermostatic Control of Temperature

Thermostatic control of air temperature in glasshouses was originally attempted by the use of one thermostat in the glasshouse and operating on the fuel and air intake of the boiler furnace. This system was found to be unsatisfactory, because during a long

period of bright sunshine, through which the fuel supply was greatly reduced, the water in the boiler and piping system cooled to a very low temperature. The result was that when the glasshouse air temperature dropped a considerable time elapsed before the water could be reheated and began to offset the outside temperature influence.

To overcome that disadvantage two thermostats are now installed, one in the centre of the glasshouse about 5ft. above ground level and one in the boiler house on the outflow pipe from the boiler. The thermostat established on the outflow pipe regulates the fuel and draught intake of the furnace to keep the temperature of the water in the boiler between 120 and 150 degrees F., irrespective of the glasshouse air temperature. This means that a supply of water at the required temperature is always available. The thermostat in the glasshouse controls the flow of water in the circulating pipes; thus when temperatures rise the circulation is stopped and when temperatures fall again circulation restarts. Dual control ensures that water at the correct temperature is always available when required for circulation through the glasshouse.

Although thermostatic control is helpful, it is not sufficient and for satisfactory growth of the plants intelligent supplementary adjustment of ventilation is essential.

Control of conditions has to be related to the stage of growth, the kind of growth desired, and the prevailing weather. For tomato crops a slowly changing fresh atmosphere without draught is best. Ventilation is therefore related to heating and it is usually better to allow ventilation and use fire heat to keep up the temperature of the house than to close the ventilators and save fire heat and risk a stagnant atmosphere. During bright sunshine the temperature of the house can be allowed to rise considerably, as there is light to balance the heat, but in dull weather the temperature should be kept slightly below normal if the desired sturdy growth is to be obtained. High temperatures during dull weather, with no sunlight to balance them, tend to induce weak, soft growth.

Types and Number of Pipes Required

The number of rows of pipes required to heat a glasshouse depends on the climate. The installation should be capable of maintaining the minimum temperature necessary for tomatoes in the coldest weather likely to be experienced. Glasshouses 30ft. wide are usually provided with four rows of pipes, sometimes arranged with two pipes along each side wall, but preferably with four pipes more or less evenly spaced over the width of the house. Sometimes six rows of pipes (two flow and four return) are fitted.

When a circulation pump is fitted pipes 2in. in diameter may be used. Usually, however, 4in. piping is preferred. Cast iron piping is the best, but owing to shortages other types of pipe are often used. Socket joints are the easiest to make and maintain, but rubber-lined expansion joints and even screwed joints are sometimes used.

Portable Heaters

Some glasshouses are heated by portable braziers placed at intervals down the centre pathways of the houses, each having a long flue to give additional heating surface. They are fired separately by hand with coke and are usually lit in the late afternoon and kept going all night. In very severe weather they are kept going during the day also. Operating costs and initial costs of this system are very much lower than those of more modern installations. However, the heaters require a great deal of attention and excessive labour is required for firing the braziers.

Portable kerosene heaters of the ordinary round-wick type are used to some extent in the Auckland district to offset frost. Most of the commercial glasshouses in this district are unheated and as an insurance against damage from occasional frosts these heaters are very satisfactory. They are lit in late evening and are placed at intervals along each side of the house about 3ft. in from the wall, one heater to each 500 sq. ft. of house. Their fuel capacity is sufficient to keep them burning for about 8 hours.

Use of Electricity

Electricity is not economical at present costs for air heating of glasshouses. The use of electricity for soil warming, however, may become more general as power becomes available.

Diseases and Pests

THROUGHOUT New Zealand tomato plants and fruit are subject to the ill effects of certain fungous, bacterial, and virus diseases, physiological disorders, and insect pests. Their individual and/or combined capacity to damage crops constitutes a major production problem. Control is largely dependent on knowledge of, and ability to identify, the causes of injury to plants or crops.

Common diseases and pests of tomatoes grown in glasshouses are:—

Fungous Diseases

Late Blight

Late blight, caused by the fungus *Phytophthora infestans* (Mont.) de Bary, affects outdoor tomatoes and potatoes mainly, but it can cause serious damage to tomatoes grown under glass. The disease may attack plants at any stage of growth and its development is favoured by warm, wet conditions.

Late blight appears first on the leaves and leaf stalks as greenish brown to black areas. Under favourable conditions and when no control measures are taken development of the disease is rapid and stems and fruit will become infected. Fruits develop russet brown, marbled areas and eventually shrivel and turn brown.

Control: Spraying with Bordeaux mixture 3 : 4 : 50 or certified Bordeaux substitutes will give effective control of late blight, but the following factors must be considered:—

Late blight *(Phytophthora infestans)* infection on stem of tomato plant.

Spraying should begin when the plants are in the seedling boxes.

Applications should be made at 10-day intervals.

Complete coverage of plants is essential.

When infection appears in crops in glasshouses humidity should be kept to a minimum by providing adequate ventilation and discontinuing watering until control is obtained.

Diseased refuse should be burnt and not dug into the soil.

Verticillium Wilt

Verticillium wilt, caused by either *Verticillium albo-atrum* Reinke and Berth or by *Verticillium dahliae* Kleb., is very common in most of the tomato growing districts in New Zealand and is a major problem with glasshouse crops. Generally the disease is not noticeable until the plants have developed 3 to 5 trusses of fruit. The first indication is usually wilting of the terminal shoots, but

Verticillium wilt. Healthy plant (left) and infected plants (middle and right).

Sclerotinia disease, showing sclerotia (or fruiting bodies of the fungus) embedded in the pith of a tomato stem.

sometimes the only visible symptoms are stunting of the plants and yellowing of the lower leaves.

In the early stages of an attack the plants may recover partially overnight, but infected plants eventually collapse, the leaves turn brown, and with severe infection plants die. The stems of infected plants will show an internal light brown discoloration and this is generally evident throughout the plants.

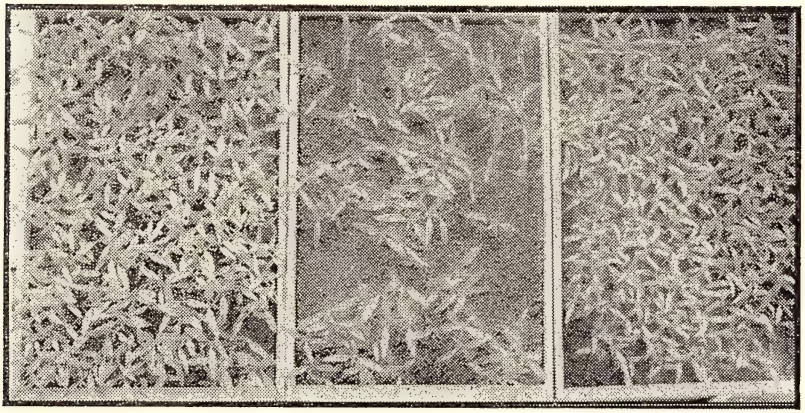
Verticillium wilt infection enters the plant through the roots, and the fungus can remain active in the soil for several years. The disease can be spread to clean soil by taking plants there from infected soil.

A check in growth or excessive watering can increase the severity of the disease.

Control: Disinfection of the soil both in glasshouses and seedling boxes by steam or chemicals is the only effective means of controlling this disease. If infection is slight, moulding up of plants to induce new root growth, whitewashing the glass to cause shading, and light overhead watering to allow a reduction of the amount of water applied to the soil will be helpful.

Fusarium Wilt

Fusarium wilt, caused by the fungus *Fusarium bulbigenum* Cke. and Mass., although seldom seen affecting indoor tomato crops in New Zealand, is mentioned here because the symptoms closely resemble those of verticillium wilt and the two diseases could be confused. Although the plants wilt and gradually die, the roots and bases of



Damping off disease. The middle box of plants was partly destroyed by infection; the boxes at left and right, the soil of which had been treated, were unaffected.

stems are also attacked and may turn brown or rot. The discoloration as described for verticillium wilt will be found on infected plants, but seldom extends more than 1ft. above the bases of plants. As this disease is favoured by high temperatures, it may be checked by keeping temperatures down to 65 to 70 degrees F. In addition the same control measures as for verticillium wilt should be adopted.

Sclerotinia Disease

Sclerotinia disease is caused by the fungus *Sclerotinia sclerotiorum* (Lib.) de Bary. Although it is seldom seen on glasshouse tomato crops, it could become serious, particularly in unheated glasshouses. The disease usually affects the stems of plants at some point above ground level and the affected areas become bleached in appearance. Infection is followed by wilting of the foliage and eventually plants die. If the affected portion of a stem is cut open, hard, black, irregular-shaped bodies will be found lining the hollow portion. Infected plants should be removed and burnt.

Foot rot *(Phytophthora cryptogea)*. Infected tomato plant (left) and healthy plant (right).

Control: Sprays are of little value in the control of this disease; the only remedy is to disinfect the soil with steam or chemicals before planting the next crop of tomatoes.

Damping off

Damping off, a fungous disease caused by *Pythium* and *Corticium* spp., may attack seedling plants at any stage from seed germination until plants are about 2in. in height. Infected plants show light brown water-soaked areas just above ground level and later the stems shrink, causing the plants to fall over. The disease is very rapid in its action.

Control: Effective control can be obtained by disinfecting both potting soil and seed trays with steam or recommended chemicals.

Tomato leaf mould *(Cladosporium fulvum)*. Early infection showing on under sides of leaves.

Foot Rot

Foot rot is caused by the fungus *Phytophthora cryptogea* Pethybr. and Laff. and has in some seasons caused concern to several growers of indoor tomatoes. Infection may occur on plants in seedling boxes and after they have been set out in the glasshouse. Symptoms are browning and rotting of the bases of the stems, and rotting of the roots.

The first noticeable symptom is wilting of plants.

Often trouble is accentuated by wet soil causing some of the roots to decay and thus allowing the fungus to gain entry.

Control: Drainage should be improved, and to avoid further contamination of the soil, where the fungus can survive for a long time, affected plants should be dug up and burnt. Soil and boxes for the raising of plants and soil in the glasshouse should be disinfected with steam, chloropicrin, or formalin.

Leaf Mould

Leaf mould, a most troublesome disease which attacks tomatoes only, is caused by the fungus *Cladosporium fulvum* Cke. Some varieties are more susceptible to attack than others. The infection usually starts in the bottom leaves of plants and works upward, sometimes affecting blossoms and fruit trusses. When first seen the mould shows as a silvery scale on the undersides of leaves and later turns to a tawny brown. Under favourable conditions the lesions enlarge into downy white bands with velvet-like centres.

The corresponding upper surfaces of leaves turn yellow, and if infection is not controlled, it will cause leaves to dry up. If flowers are attacked, they may fail to set fruit. Early infection, if uncontrolled, will materially affect production.

Control: Efficient control of leaf mould can be obtained by ventilating freely, by avoiding excessive watering, and by allowing plants ample space. Free circulation of air around plants assists in keeping down local humidity and this can be aided by removing the lower leaves up to the first truss. Spraying the plants with a certified salicylanide preparation at the recommended concentration from soon after they are set out and before the disease appears is recommended in localities where the disease is difficult to control by improving ventilation and reducing humidity.

Grey Mould

Grey mould or botrytis rot of tomatoes is caused by the fungus *Botrytis cinerea* Fr. and can reach serious proportions under favourable conditions on indoor tomatoes. Infection causes damage to stems, fruits, and flowers. The fungus gains entry through leaf scars and any damaged or dead tissues. On stems and leaves it appears as water-soaked, greenish brown lesions which soon develop into a greyish brown velvet-like mass. As the fungus progresses it may encircle the stem and cause the parts of the plants above the infection to die. Fruit is usually attacked at the stem or blossom end and decays rapidly. Spore masses similar to those on stems sometimes envelop the decayed fruit. Other symptoms sometimes seen on fruit and known as ghost spot are round marks about $\frac{1}{8}$in to $\frac{1}{4}$in. in diameter dotted over the fruit surface. These markings, although blemishing the fruit, do not cause them to decay.

Grey mould marking on tomato.

Control: Reducing humidity by free ventilation and careful watering will usually control the disease. Other measures that should be adopted are pruning to avoid leaving dead tissue and broken foliage, and removal and burning of all infected material such as dead leaves and fruits, both from the plants and the ground. As the spores fly readily, it is recommended that several containers filled with equal parts of water and kerosene should be kept in the glasshouse and that the infected material should be placed in these containers to prevent the spores of the fungus flying and alighting on the plants.

Two new fungicides which are giving good results in the Auckland district in controlling botrytis are ferbam and thiram wettable powders. Thiram is sprayed on the whole plant, but ferbam is applied to the flowers only. Fifty per cent. thiram wettable powder is used at the rate of 2lb. to 4lb. per 100 gallons of water and is applied at intervals of 10 days from the time the first sign of the fungus appears until satisfactory control is obtained. Seventy per cent ferbam wettable powder is mixed with the fruit-setting hormone and is used at a concentration of 4/5oz. to 1 gallon of fruit-setting mixture. When this mixture is applied the flower trusses should be wetted back and front and the application should be repeated in 10 days.

Bacterial Diseases

Tomato Canker

Tomato canker, caused by the bacterium *Xanthomonas michiganensis* (Smith) Dowson, is sometimes found on a few tomato plants in glasshouses, but so far has caused no serious loss.

The disease attacks both young and old plants. Young plants may

Tomato canker. Upper—Raised, scab-like markings on ripe fruit. Lower—Early infection on stem—dark staining of the vascular area and pith.

wilt and die or remain stunted. When older plants are attacked the bottom leaves wilt and later turn brown and die and it is some time before the upper foliage of plants dies.

At first no infection shows on the stems, but as the disease progresses the stems shrink and split lengthwise. The pith becomes shrunken and dark brown and a light brown discoloration appears in the remainder of the inside of the stem. Infection may show on the skin of the fruit as white spots with rough, raised centres.

The disease is readily transmitted on seed from infected fruit, or it can be spread by watering, cultivation, or pruning.

Control: The following precautions are recommended:—

Use disease-free seed or disease-free plants.

Extract seed by acid method (see page 7).

Treat seed of unknown origin with acidulated mercuric chloride.

Disinfect soil used for raising plants and soil in glasshouse.

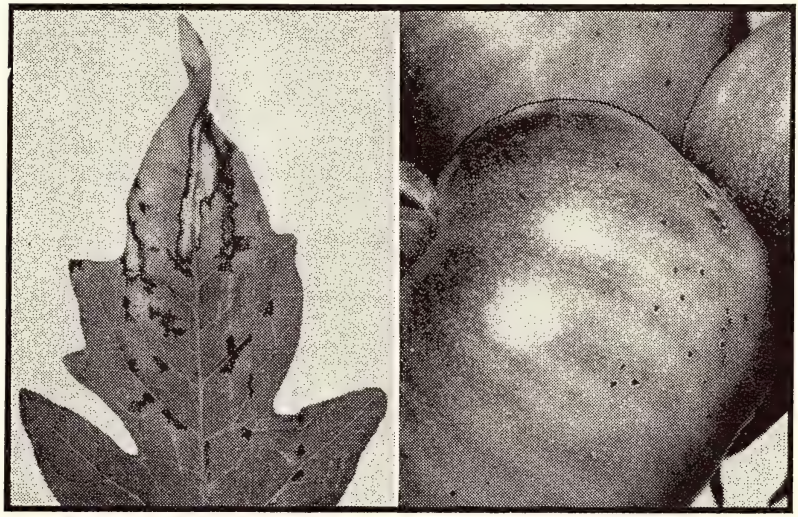
Burn any infected plants.

Tomato Speck

Tomato speck is caused by *Bacterium tomato* (Okabe) Magron and though more common on outdoor plants, where it has caused serious losses, it occasionally affects indoor plants.

The disease appears on the leaves as dark brown, rough, irregular spots about $\frac{1}{8}$in. in diameter. Later the spots increase and the leaves become brown and dry up. Tiny, round, raised, black specks surrounded by a distinct white margin occur on the fruits. The specks remain on the surface and are not deep seated.

Control: The disease is thought to be carried on the seed and for this reason seed of doubtful origin should be treated. Seed treatment was described on pages 7 and 8. As the disease sometimes occurs on young seedlings and is easily spread



Tomato speck on leaf (left) and green fruit (right).

by watering, care should be taken to see that the plants to be set out in the glasshouse are healthy. Other control measures are the same as for tomato canker.

Virus Diseases

Tomato Spotted Wilt

Tomato spotted wilt, commonly called bronze top, is a most serious virus disease, as it often kills the plants. Infection shows first as dark, pin-point spots on the terminal shoots and leaves. The top of the plant soon becomes stunted, the young top leaves tend to curl downward, and little or no further growth is made. Irregular brown and bronze markings appear on the leaves as the disease progresses through the system of the plant, and fruits show irregular mottling of lighter or yellowish colour or distinct concentric markings.

Control: Control measures consist of removing and destroying infected plants as soon as the disease is noticed. As the disease is spread from plant to plant by onion thrips (*Thrips tabaci*), these should be controlled by fumigating the glasshouse with nicotine sulphate (see page 43).

Spotted wilt (bronze top) on leaf.

Cucumber Mosaic

Cucumber mosaic has not so far been of economic importance on glasshouse tomato crops. Symptoms may appear at any stage of growth, but the dsease more often affects plants at the early fruit-bearing stage. It causes narrowing, distortion, and curling of the leaves, which reduce the vigour of the plant and result in the production of small, lightweight fruit.

Control: The disease is most commonly spread by aphides which feed on a wide range of plants, some of which could be hosts for the virus. It can also be spread by workers during pruning. Except that healthy plants should not be handled after diseased ones until the hands have been washed with soap and water, the control methods are similar to those for spotted wilt.

Cucumber mosaic on tomato plant, showing narrowing and distortion of leaves.

Tobacco mosaic on tomato leaf.

Tobacco Mosaic

Tobacco mosaic is by far the commonest virus disease of glasshouse tomatoes. Although it is not as serious in its effect as spotted wilt, it can cause a fairly severe reduction in yield. The virus causes a mottling of the leaves which is sometimes accompanied by leaf distortion. The mottling shows as

light yellowish green, irregular areas in the leaf-blade tissues. The fruit is sometimes affected and may show slight irregularity or "mistiness" in the red colouring. The virus may be spread by the hands from plant to plant when laterals are being removed or during tying operations. Mosaic also affects tobacco and is usually present in the manufactured product. It may be spread to tomato plants by workers who handle tobacco in rolling cigarettes.

Control: As the virus can be carried in the gelatinous coat of tomato seed, all seed saved should be acid treated.

Where the virus was present in the previous crop steam treatment of the glasshouse soil (see page 12) is the only known remedy. This applies also to potting soils that are known to contain the virus. Where steam disinfection is not possible some control may be obtained by removing all plants, including their roots, as soon as the crop is finished and sowing the area down to maize. The maize crop should be watered freely during its growth and again after digging in to wash the virus out of the topsoil.

Before being planted out in the glasshouse all plants should be carefully inspected and if virus infection is visible on any the whole box of plants should be discarded.

Workers who smoke should wash their hands with soap and water before handling plants.

If only a few plants are noticed in the glasshouse, they are best removed with the soil surrounding them and replaced with fresh soil and plants.

Tomato Streak

Tomato streak is common, but although it reaches serious proportions occasionally, it is usually confined to a small percentage of the plants in any one crop. The characteristic symptoms are black streaks on the stems and leaf stalks. These later become sunken. The

Tomato streak, showing sunken areas and markings on green fruit.

Blossom-end rot. Advanced stage, showing sunken areas on blossom ends.

leaves may become brown and shrivelled and the young leaves may have a slight mosaic mottling. Symptoms usually appear when the plant is at the fourth- or fifth-truss stage. Badly infected plants are retarded in growth and usually drop a considerable amount of their foliage, and the fruits, if they set, usually have sunken areas which give them a pock-marked appearance.

Control: Tomato streak and tobacco mosaic are strains of the same virus and control measures are similar.

Physiological Diseases

Physiological troubles are attributed to some cause other than living organisms or virus and are brought about by unfavourable factors in the general conditions of growth. A disturbed water supply, adverse weather, or chemical injury may produce symptoms that appear to be due to disease. Tomatoes are especially subject to several physiological conditions of this nature, and the main ones affecting them in New Zealand are those which follow.

Blossom-end Rot

Blossom-end rot is not very common in tomatoes grown under glass and affects the fruit only. The causal agent is not disease and the condition has been attributed to sudden fluctuations in moisture, which result in the collapse of the cells at the blossom end of the fruit. Lack of water during the period of maximum fruit expansion followed by an excess of moisture appears to create the most favourable conditions for the development of blossom-end rot. In its early stages the trouble appears as a small spot at or near the blossom end of the tomato and at this stage the affected area has the appearance of a bruise, being water soaked and dark green. As the size of the affected area increases the tissues become firm, leathery, and brown to black. At times the whole of the blossom end of the fruit becomes flattened and black.

Control: Losses from blossom-end rot can be minimised by keeping an adequate moisture supply in the soil throughout the growth of the crop. Excessive use of nitrogenous fertilisers such as sulphate of

ammonia or lack of lime may also cause favourable conditions for blossom-end rot.

Blotchy Ripening

Blotchy ripening, sometimes called cloud or cloudy fruit, is mainly a glasshouse trouble. It occurs in most areas in New Zealand. It usually appears on the fruit of the first truss when it is nearing maturity. Hard, dark green patches develop on the fruit at first. Underneath these patches the flesh is dark brown or black. As the fruit ripens the green patches turn yellow and are quite distinct from the bright red of the healthy tissue. This fruit, although edible, loses much of its marketable value. Blotchy ripening occurs mainly when crops are heavy and usually affects the first three trusses. This condition is thought to be related to the food supply. Light, water supply, and available plant foods all seem to influence the development of the trouble, but so far it has not been possible to find out which factor or factors are the main cause.

Hollow Fruit or Puffy Fruit

Hollow fruit or puffy fruit occurs occasionally and affected fruits, because of their light weight and flabby condition, are of low market value. Affected fruits when handled are soft and flabby and when cut open have hollow pockets between the seed-bearing pulp and the outer layer of flesh. The flavour of the fruit is not affected and they keep as well as firm tomatoes, but collapse badly when packed. A somewhat similar condition can be brought about on fruit by hormones of the 2,4-D group, but such fruit is often seedless.

Control: There is no simple remedy. It appears that several factors are responsible for the development of hollow fruit. Great fluctuations in temperatures and soil moisture appear to make conditions favourable. An unbalanced plant food supply brought about by the application of large quantities of nitrogenous manures and only small quantities of phosphates may also increase this trouble. Some varieties are more susceptible than others.

Fruit Splitting

Fruit splitting has been evident in recent seasons on at least two varieties of tomatoes, Potentate particularly being affected. It is of minor importance, as it is usually confined to a few fruits on the three bottom trusses. When the fruits are very young they crack open at the side or blossom end. These cracks enlarge as the fruit grows and expose some of the partly grown seed. Tissues lining the injury become dry and hard.

As at present the cause is unknown, no control measures can be recommended.

Leaf Twist

Leaf twist is fairly common on the Potentate variety and in some instances affects a large percentage of plants. In conjunction with the downward twisting the leaf stalks become very brittle and break off easily when handled.

The symptoms occur mainly near tops of plants and if the under sides near the bases of the leaf stalks are examined, dark, scabby streaks will be found. Stalks become very brittle and leaves will break off easily when plants are being trained. Later the trouble may disappear, possibly because of better growing conditions.

The cause of this trouble is unknown. Extra care when handling plants to avoid breaking off too many leaves will reduce damage. It has been found that plants are less likely to be damaged if work is done on them during the hottest part of the day.

Hormone Weedkiller Injury

Tomato plants are most susceptible to injury from hormone weedkillers and use of these substances close to tomatoes has in several instances caused serious damage. The first effects on the plants are spiral twisting of growing points and leaf stems and drooping of leaflets. About 2 weeks after plants have been in contact with hormones extreme narrowing and curling of affected leaves becomes apparent. Plants keep growing, but in most instances the new growth is abnormal and fruit formed is distorted and hollow.

The leaf symptoms of hormone weedkiller injury are very similar to those of cucumber mosaic (see

page 36). Very minute quantities of weedkilling hormones will damage tomatoes, and injury can be brought about by drift from spray, by vapourising of volatile products used nearby, or by spraying the tomato crop with pumps previously used for weedkilling sprays.

Tomato leaves showing typical 2,4-D damage.

Insect Pests

The number of insect pests which attack indoor tomato plants in New Zealand is not great, but some of them can very seriously reduce production.

Stem Borer

Stem borer (*Gnorimoschema plaesiosoma* Turn.) can become a major pest in some localities. Plants are frequently lost through the ravages of the larvae of the tomato stem-borer moth. Eggs are laid on the leaves of tomato plants and the young caterpillars tunnel into the main stems, often causing plants to collapse.

Control: D.D.D. 25 per cent. wettable powder, 1lb. in 50 gallons of water, will give control and may be combined with other sprays used on tomatoes. Applications should be made when the plants are in the seedling boxes, at which stage infestation usually occurs. Special attenion should be given to see that the stems of plants receive complete coverage.

White Fly

White flies (*Trialeurodes vaporariorum* Westw.) are small sucking insects that live on the sap, and if left uncontrolled, they can cause serious damage to glasshouse plants. Heavily infested plants become unthrifty in appearance and the foliage may wither and die. When plants are disturbed the flies rise into the air in large numbers. The insects secrete a honey dew, on which develops a mould fungus that gives plants and fruit a sooty appearance.

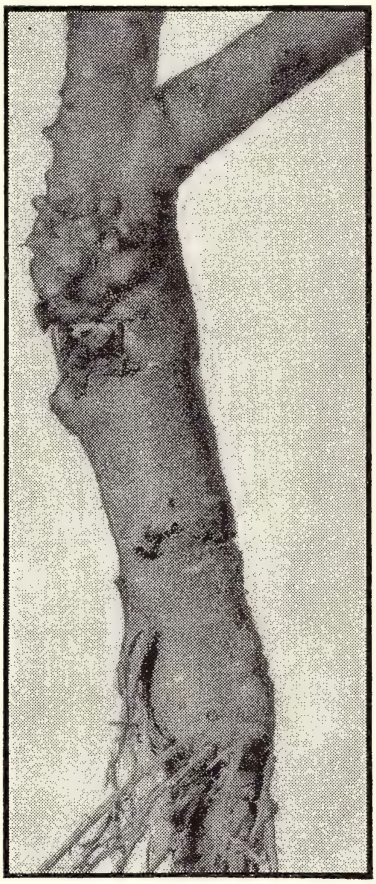
Control: Care should be taken to ensure that white fly is not introduced on seedling plants. White fly can be controlled by spraying or fumigating with nicotine sulphate (referred to later) or with the aerosol method of applying D.D.T. at recommended rates, and when temperatures exceed 70 degrees F. Dosages may have to be increased if the glasshouse is not reasonably airtight.

Tomato Mite

Tomato mite (*Phyllocoptes lycopersici* Tryon.) appears only occasionally in glasshouse tomato crops, but if control measures are

not taken, it can be very damaging to the plants and fruits. It will attack plants at all stages of growth, but is seen mainly on well-developed plants. The first visible symptom is a bronzing of the tomato stem caused by injury to the skin, and the fruit may appear rough and brown. Heavy infestation will cause the leaves of the plant to curl and dry up.

The insect is so small that it cannot be seen properly without a lens and appears to the naked eye more like a fawn dust. It multiplies rapidly and it is therefore important to control it before infestation becomes severe.



Dwarf tomato showing typical external symptoms of stem borer infestation in main stem near ground level.

Control: To ensure control of this pest it is essential that all parts of the plants are treated, and fumigation of glasshouses with nicotine sulphate is the most effective method. In glasshouses not sufficiently airtight for fumigation spraying with nicotine sulphate is best. If the insects are noticed early, it may only be necessary to spray infested and adjoining plants. The mites can easily be carried on the clothing and care should be exercised to avoid spreading the pest in this manner.

Aerosol nicotine sulphate is also effective for control of tomato mite. It should be applied at recommended dosages and when temperatures exceed 70 degrees F. Dosages may have to be increased if the glasshouse is not reasonably airtight. A respirator should be worn when applications are being made.

Root Eelworm

Root eelworm (*Heterodera marioni* Cornu.) can be very damaging to tomato plants, as it will retard their growth and in severe cases will cause them to wilt badly. In some instances plants grow normally but produce only a light crop. Eelworms are difficult to see with the naked eye, but if the roots of affected plants are examined, they will be found to have numerous galls or nodules on them. These are caused by the eelworms, which live in the roots and feed on sap.

Control: Disinfection of infected soil by steam or chemicals (see pages 12 to 16) or its removal and replacement by clean soil are the only known methods of treatment.

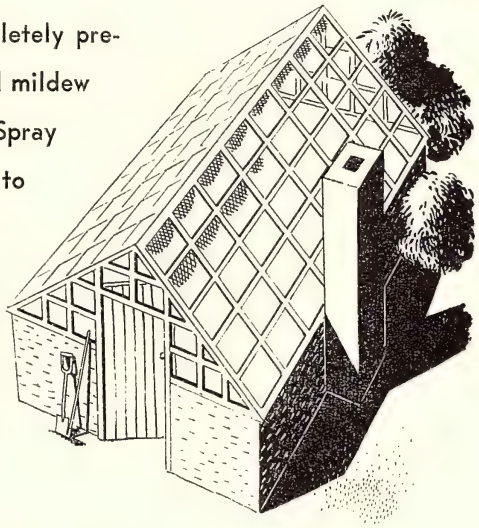
Green Aphis

Sometimes green aphis (*Macrosiphum euphorbiae* Thos.), also called green fly, is troublesome. The aphides attack the young growing shoots, causing malformation and stunting and inward rolling of the leaves. They can also spread cucumber mosaic.

Control: Plants may be sprayed or the house fumigated with nicotine sulphate (see page 43), or aerosol nicotine sulphate may be used as for control of tomato mite.

Prevent tomato leaf mould in glasshouse and garden with "SHIRLAN" A. G.

"Shirlan" A.G. will completely prevent attacks of mould and mildew in glasshouse growing. Spray at regular intervals to ensure a continuous coating over your tomato plants. "Shirlan" A.G. is non-poisonous, harmless to foliage, clean, effective and safe.



And control late blight of tomatoes with "CUPROX"

"Cuprox", the copper fungicide, is packed in powder form — just add water and stir. There is no waste, no bother, and the mixed spray lasts indefinitely. "Cuprox" supersedes Bordeaux Mixture.

BOTH PRODUCTS CERTIFIED BY THE PLANT DISEASES DIVISION

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Nicotine Sulphate Treatments

Nicotine sulphate fumigation can be used successfully to eradicate white fly and tomato mite. It is done by heating the liquid in a metal container over a small flame. One fluid ounce is required to treat 1000 cub. ft. of glasshouse space. These fumigating units should be placed so that each unit covers not more than 5000 cub. ft. Treatment is best carried out in the evening but while the glasshouse temperature is still high. All ventilators and doors should be closed beforehand. Containers holding the nicotine sulphate should be placed just above the flame and the wick of the lamp adjusted so that the liquid is volatised in about 1 hour. (See precautions below.) Next morning the house can be opened up and ventilated as usual.

The cubic capacity of the usual type of glasshouse with centre ridge may be calculated by multiplying the length by the breadth by the average height. The average height is half the sum of the height from the ground to the ridge plus the height of the outer wall.

Nicotine sulphate spray is an effective contact insecticide recommended for the eradication of white fly and tomato mite. To increase its effectiveness as a spray soft soap should be added except when it is combined with sprays containing hydrated lime. It should be used at a concentration of 1 gallon to 800 gallons of water (1 pint to 100 gallons) plus 3lb. of soft soap per 100 gallons.

Nicotine sulphate aerosols are recommended for the control of tomato mite, aphis, and white fly. They should be applied at recommended dosages in late afternoon after the glasshouse ventilators and doors have been closed and when the temperature is above 70 degrees F. A respirator should be worn when applications are made. The glasshouse should be kept closed overnight and should be well aerated before it is worked in next morning.

Precautions

The following precautions should be observed when nicotine sulphate is used:—

1. Avoid contact of concentrate with skin or mouth and use rubber gloves if hands have open cuts.
2. Immediately wash off concentrate spilt on the skin with soap and running water. After spraying cleanse all exposed parts in a similar manner.
3. Keep insecticide out of reach of children.
4. Do not eat, drink, or smoke while spraying.
5. Leave the glasshouse if inhalation of spray vapour causes headaches and tightness of the chest.
6. When a glasshouse is being fumigated with nicotine sulphate and the lamps have been lit do not enter the house without a respirator or enter it only after it has been ventilated.

[All photographs in section on diseases and pests, except that at top of page 30, by Department of Scientific and Industrial Research.]

References

"Tomato Diseases and Pests in New Zealand and Their Control", by J. D. Atkinson, R. M. Brien, E. E. Chamberlain, N. Cottier, H. Jacks, W. D. Reid, and G. G. Taylor (1949).

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"Tomatoes", Bulletin No. 77 of the British Ministry of Agriculture and Fisheries.

Most of the material in this bulletin appeared in the May and June 1953 issues of "The New Zealand Journal of Agriculture".

NOTES

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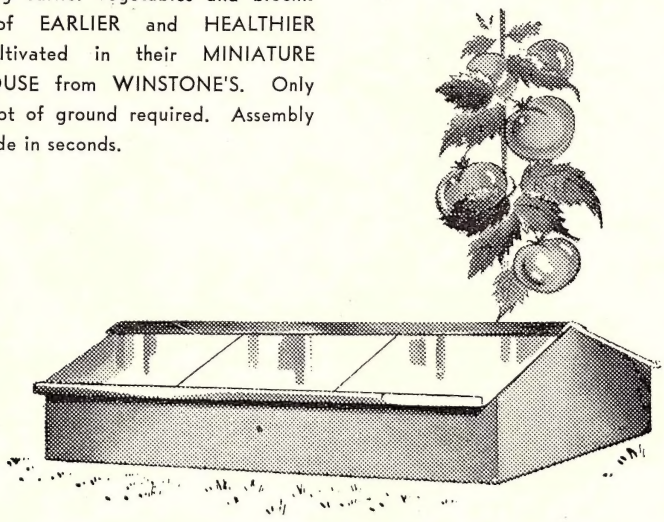

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